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June 14, 1962

U S Army Corps of Engineers
GIMRADA
Fort Belvoir, Virginia

Attention:

Chief, Intelligence Division

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Subject: Change Detector Program
Unsolicited Proposal for

Reference: (A) Letter X51-AD3605, 6 April 1962

Enclosure: (1) Supplemental Work Statement
(2) Supplemental Costs Proposal

Gentlemen:

This letter supplements our letter of quotation, reference (A), and its enclosures.

The quotation provided in reference (A) remains firm through 15 July, 1962.

Supplemental work, described in Enclosure (1), will be provided at \$12,769 additional cost on a cost-plus-a-fixed-fee type of contract.

Please see Enclosure (2) for cost breakdown.

Yours very truly,

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Enclosure (1) to letter to U S Army, Corps of Engineers
dated 14 June 1962

SUPPLEMENTAL WORK STATEMENT

During the predesign study, will
investigate the problem of utilizing multi-format input data to
the change detector.

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Consideration will be given to the effects on the change detector
(size, weight, accuracy and cost) of changing the film transport
mechanism to handle film formats of 70 mm X 70 mm, ^{through} ~~5" X 5"~~, and
9 $\frac{1}{2}$ " x 9 $\frac{1}{2}$ " in size and in quantities up to 150 feet in length.

This investigation will be based on utilization of a standard
aperture of 70 mm X 70 mm size.

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**U. S. ARMY ENGINEER
GEODESY, INTELLIGENCE AND MAPPING RESEARCH AND DEVELOPMENT AGENCY
FORT BELVOIR, VIRGINIA**

**INTELLIGENCE DIVISION
PURCHASE DESCRIPTION**

9 April 1962

CHANGE DETECTOR

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(Exhibit B)

1. SCOPE

1.1 This Purchase Description covers the development and fabrication of a change detector that will compare two sets of imagery taken of the same geographic area at different times and will display and locate (with reference to one of the scenes) any changes that occurred between the times that the imagery was obtained.

2. APPLICABLE DOCUMENTS

2.1 The following report covers the present status of work on change detection using the approach described herein: "Change Detector Studies",

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3. REQUIREMENTS

3.1 Concept of Use

Imagery obtained for intelligence purposes must be carefully studied to extract as much information as possible. If additional coverage is obtained of the same area at a later time, the primary points of interest are most likely to be those where changes have taken place during the interval between the times that the two sets were taken. The use of a Change Detector, which would automatically display these changes, would enable the interpreter to spend his time on the most promising areas without having to do the routine time-consuming scanning of all the imagery to detect changes. Subsequent coverage could be compared with any of the earlier sets. For use in the Change Detector, imagery must have been obtained along flight lines in the same direction as the set with which it is to be compared. Scenes cannot be expected to match exactly with those from a previous mission, but the portions that do match can be compared

for changes. The two rolls of film will not cover exactly the same area; overlap will not be just the same; and alignment will vary. In fact, the lines of flight may diverge so the overlap disappears. The machine would cease to operate in such a case. If sufficient overlap resumes, the rolls will have to be realigned manually. It is expected that an operator will be needed to make the necessary display adjustments and have some part in recording the locations of the changes. If it is found desirable, the user can provide a camera which the operator would use to take photographs of the frames on which changes are shown. Or coordinates could be recorded on tape or punch cards as the operator uses a pointer or a reticle to pinpoint the locations. It is expected that the Change Detector can be used with infrared or radar imagery as well as aerial photography.

3.2 Description

The Change Detector will be a console that consists of a Comparator Unit and a Display Unit.

3.2.1 The Comparator Unit will consist of the following assemblies.

3.2.1.1 Film Transport Mechanism.^{2.5-01}- The equipment will handle two 100-foot rolls of 70 mm. film with manual and/or automatic advancement of the film on a frame by frame and/or partial frame basis. Frame counters will be included. Manual tip-tilt adjustments will be provided. Azimuth adjustment will be made by rotating one roll $\pm 90^\circ$. This assembly also will include the condensing optics and the photomultiplier readout sensors.

3.2.1.2 Lens Displacement Mechanism.^{2.5-01}- This is the optical system consisting of: the lenses (to be determined in the predesign study) that can be translated in x and y directions for displacement adjustment and axially to provide magnification for scale adjustment; and the electromechanical

servos to drive the lenses in these three directions.

3.2.1.3 Light Sources and Associated Optics. - This assembly will consist of the back-light, mirrors and lenses necessary to image one scene on the other for registration. There will be automatic transition from registration to display.

3.2.1.4 Comparator Electronics. - This assembly will include the circuitry required to drive the electromechanical components, the electronics necessary to generate the flying spot scanner, the amplification of video signals for each channel, and the high-voltage power for the photo-multiplier tubes and the cathode ray tubes.

3.2.2 The Display Unit will consist of the following assemblies:

3.2.2.1 Two Monitors. - The comparison scene monitor will display, at the option of the operator, either the comparison or reference scene, or show a "flicker" presentation. The change display monitor will present, at the option of the operator, the change display or the reference scene. There will be an option on showing changes as black or white or both. The monitors will be 14-inch TV type tubes with a 525-line raster.

3.2.2.2 Operation Controls. - These will include the control for the following operations: frame adjustment, frame advance, controls for alignment in x and y directions and scale factor for each roll of film, initiating controls for automatic registration, noise rejection, area blow-up, flicker option, video gain for contrast control of each channel, tip-tilt control, and polarity control.

3.2.2.3 Position Readout Assembly. - Capability will be provided to locate changes on the frames of the comparison roll with a maximum error of $\pm 5\%$,

measured at the film plane, as the design goal. Numerical coordinates with respect to the frame will be displayed, and analog outputs in x and y coordinates will be provided so punch card or tape equipment can be plugged in, if desired, to record the coordinates of the changes.

3.2.2.4 Display Unit Electronics. - This will include the noise rejection circuitry and all the power supplies except the high-voltage supplies.

3.3 Operation

The Change Detector will have the operational characteristics described herein. The input will be two 100-foot rolls of 70 mm. transparencies, both positive or both negative, each roll covering approximately the same geographic area.

3.3.1 Registration. - When the two rolls of transparencies are first put into the change detector, the operator will align the two rolls so that approximately the same area is shown on each scene that is in position for examination. Correlation will be automatic and/or manual by the movement of lenses and optical wedges within the following limitations:

Translation in x and y directions, with 10 to 100% overlap, design goal.

Asimuth variation, $\pm 90^\circ$.

Scale factor, 2x, minimum.

Time - initial alignment by operator less than 2 minutes, then less than 30 seconds per frame for correlation and comparison.

3.3.2 Comparison. - While the correlation system is locked in position to keep the two scenes in registration, a video-difference detector will be used to compare the two views. A flying spot scanner with the aid of a

split optical system will scan the two scenes simultaneously point-by-point. The video signals obtained from the photomultipliers will be amplified and subtracted and used to modulate the intensity of the display on the monitor screen.

3.3.3 Display.- Presentation will be on two 14-inch TV monitor screens with 525-line rasters. (This will give approximately 5x magnification for 70 mm. film.) On the comparison scene monitor (left screen) the operator can view either the reference or comparison scene or have a "flicker" presentation (he is expected to be concerned primarily with the comparison scene). On the display monitor (right screen) the operator will normally be viewing the change display, although he can switch to the reference scene. The change display will show changes as very light or very dark areas on a low-contrast gray background scene formed by the superimposed reference and comparison scenes. Automatic frame counters will be provided so the number of the frame on each roll will be conveniently displayed. The counter numbers will be adjustable so they can be set to coincide with any numbers between 001 and 999 that may be on the photo frames.

3.3.4 Variable Magnification.- Normal screen presentation will magnify the input transparencies approximately 5 times. Variable magnification will be provided so any portion of the film can be blown up approximately 40 times for more detailed examination when desired.

3.4 Auxiliary Equipment.-

In addition to the Change Detector console, the Contractor shall also furnish the following Auxiliary Equipment as a part of this contract:

3.4.1 Briefing Materials.- The Contractor will furnish GIMRADA with the

following briefing aids: briefing charts (not more than 30) prepared in accordance with Corps of Engineers standards; a 35-mm. color slide of each chart; and photographs of the various components of the Change Detector as the work progresses.

3.4.2 70-mm. Splicer. ✓

3.4.3 USAF Resolution Chart. ✓

3.4.4 Set of final Assembly Drawings and Circuit Schematics. ✓

3.4.5 Chair. The Contractor will provide an adjustable chair for the operator to use. ✓

3.5 Manuals.-

3.5.1 Operation Manual. The Contractor will furnish ten (10) copies of an "Operation Manual" for the Change Detector.

3.5.2 Maintenance Manual. The Contractor will furnish five (5) copies of a "Maintenance Manual" for the Change Detector.

3.6 Problems.- The Contractor will give consideration to the following problems in his development and design of the Change Detector.

3.6.1 Unwanted Changes. Major problem in the development of the Change Detector will be the unwanted changes such as those caused by differences in season (vegetative cover) and time of day (shadow differences). Other such variables are cloud or snow cover, improper exposure, and soil moisture conditions. Such differences would normally be shown as changes unless provision is made to reject such data. It may be possible to adjust clipping levels to the video signals to prevent some of these differences from being shown on the screen. Provision will be made for rejecting unwanted changes and noise as effectively as possible.

3.6.2 Angular Displacement.-- Any object that is photographed from two different points in space will have some difference in appearance on the photos. If both views are nearly vertical or taken from approximately the same angle, the differences between the two images will not be great enough to affect the performance of the Change Detector. If the difference in position is great enough to significantly modify the image, the perspective differences will be shown as changes. Oblique views taken from different points will have varying scales, which, if extreme enough, may make correlation impossible. Tests will be made to determine the maximum angular difference that the Change Detector can tolerate without showing perspective differences as changes.

4. PROGRAM

4.1 Tasks.--

The Change Detector program has been divided into four major tasks: System predesign study, Display processing studies, Design and fabrication of prototype model, and Evaluation.

4.2 System Predesign Study.--

Some predesign studies will be necessary before the design can be finalized. Some of the items that will be investigated are: selection of lens system with accurate resolution and fidelity to permit accurate scene registration, console configuration, tolerances on various mechanical and electrical components, method of film loading and frame advance, method of masking the scenes for correlation, and type of position read-out. The Contractor will consider the effects of changing the film transport mechanism to handle multi-format inputs of film from 70 mm. to 9 inches in size,

although only the area of a 70 mm. format would be under examination at a time. The Contractor will furnish his recommendations concerning this modification to the present concept of the Change Detector to handle these formats.

4.3 Display Data Processing Studies.-

Studies will be made to determine the display presentation that will furnish the optimum data to the operator. The various display options require further study. Methods of displaying the actual changes will be investigated. There will be some noise and unwanted changes that will clutter the screen and make it difficult to pick out the important changes. Shadows and clouds can probably be rejected using a "clipping" technique. Seasonal and perspective changes present a greater problem. This study will investigate any technique which could improve the capabilities of the equipment to eliminate the unwanted changes.

4.4 Design and Fabrication.-

The prototype model will be designed and fabricated to meet the requirements listed in paragraph 3 above and the decisions made based on the results obtained from the Predesign and Display studies described in paragraph 4 above. Some of these studies will overlap the design and fabrication stage, as time is limited, but certain phases of design can be started before all the results of these tests are needed.

4.4.1 The Change Detector will be designed to require a minimum of maintenance. Design will be such that any routine maintenance can be handled by an operator who does not have any prior experience with maintenance of electronic devices.

4.4.2 Standard designs, components, and equipment including electronics will be incorporated into the Change Detector whenever possible.

4.4.3 There are three major areas of activity in this phase: (a) the optical and electromechanical parts required to perform image correlation and film handling; (b) the electronics required to perform the image registration, data comparison, and display data processing; and (c) the console and equipment to integrate all these components into the final assembly.

4.5 Evaluation.-

The prototype model will be adequately tested by the Contractor during the period of the contract to assure ~~themselves and the Project Engineer~~ that it will operate satisfactorily and will require limited maintenance.

5. QUALITY ASSURANCE PROVISIONS

5.1 Inspection.-

The equipment shall be subject to inspection by the Project Engineer during and after manufacture to determine the conformance with the requirements of this Purchase Description.

5.2 Tests.-

The Change Detector shall be given such tests as may be necessary to determine conformance with the requirements of this purchase description. Final acceptance will be made prior to delivery by the contractor.

6. PREPARATION FOR DELIVERY

6.1 Packing.-

Packing for shipment shall be in such a manner as to insure acceptable and safe delivery to the designated point (Fort Belvoir or within the

Washington, D. C. area) by common carrier at the lowest rate of the carrier.

6.2 Marking.-

Marking for shipment shall conform to the requirements of Standard MIL-STD-129, "Marking for Shipment", except as may be modified by the Contracting Officer.

7. NOTES

7.1 This purchase description is intended for procurement of experimental equipment. It does not necessarily include requirements recommended by the U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency, or the U. S. Army Corps of Engineers for procurement of this equipment for general use.

7.2 Notice.-

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any potential invention that may in anyway be related thereto.

EXHIBIT "A"

DESCRIPTION OF WORK AND/OR SERVICES

1. a. The Contractor shall furnish all services and materials necessary (other than those to be furnished by the Government, as hereinafter provided for) to design, develop, fabricate, test, and deliver f.o.b. Fort Belvoir, Virginia, one (1) Change Detector and Auxiliary Equipment in accordance with the requirements set forth in USAEGIMRADA Purchase Description entitled "Change Detector", dated 9 April 1962, copy of which is attached hereto marked Exhibit "B" and made a part hereof. The Change Detector and Auxiliary Equipment shall be ready for acceptance tests at the Contractor's plant within eighteen (18) months from the date of the contract. Duration of the contract shall be for twenty (20) months.

b. Prior to fabrication of the equipment to be furnished under 1.a. above, the Contractor shall submit to the Project Engineer, for approval, one (1) complete set of preliminary drawings of the Change Detector. The preliminary drawings will show the complete layout of the console, the identification and location of all components, and other details necessary to reveal the complete design. The Project Engineer will conduct the review of the preliminary drawings within twenty (20) days after receipt of the drawings.

c. Upon receipt of written approval from the Project Engineer of the drawings submitted under 1.b. above, the contractor shall make such corrections and/or modifications as required by said approval, although such corrections and/or modifications shall in no way relieve the Contractor of responsibility for the equipment meeting the requirements of Exhibit "B". The Contractor shall fabricate, test, and deliver the Change Detector and Auxiliary Equipment.

2. a. As a part of the work and services to be performed hereunder, the Contractor shall furnish and deliver f.o.b. GIMRADA, Fort Belvoir, Virginia, the following reports in accordance with the Purchase Description "Reports, Technical, Contract", dated 21 November 1960, copy of which is attached hereto and marked Exhibit "C" and made a part hereof.

(1) Type I - Letter progress reports, ten (10) copies within ten (10) days after the close of each month.

(2) Type II - Interim technical report, fifty (50) copies to be submitted approximately twelve (12) months after the contract date.

(3) Type III - Final technical report, draft to be submitted within eighteen (18) months after the date of the contract to the Project Engineer for review and approval within twenty (20) days. Fifty (50) copies of the final approved report will be submitted by the Contractor within thirty (30) days after receipt of the approved draft.

3. a. The Contractor shall provide an Operating Manual and a Maintenance Manual.

b. Prior to delivery of the manuscripts to be furnished under 3.a., the Contractor shall submit to the Project Engineer for review and approval two draft copies of each of the proposed manuscripts within seventeen (17) months after the contract date. The Project Engineer shall complete his review within twenty (20) days after receipt of the draft copies and return the approved copies to the Contractor, who will prepare and deliver ten (10) copies of the Operating Manual and five (5) copies of the Maintenance Manual to GIMRADA within nineteen (19) months after the contract date.

4. a. Upon completion of the fabrication of the Change Detector, a set of final assembly drawings and circuit schematics will be furnished by the

Contractor.

b. The Contractor will provide training in the basic operation and maintenance of the Change Detector for three Government personnel for a period of three to five days to be conducted at the Contractor's plant. The date will be shortly after the fabrication is completed, to be established for the convenience of the Government.

SPECIAL PROVISIONS TO EXHIBIT "A"

1. The Government will furnish the Contractor f.o.b. the Contractor's plant with the following items:

a. Thirty (30) sheets of cardboard, with the red banner and castle affixed, on which the Contractor will prepare the briefing charts. The completed charts will be returned to GIMRADA.

b. Several exposed rolls of 70 mm. film which can be used in the Change Detector. This film can be retained by the Contractor.

CHANGE DETECTOR CONSOLE

Comparator Unit
Display Unit

Comparator Unit

Film Transport Mechanism
Lens Displacement Mechanism
Light Source and Associated Optics
Comparator Electronics

Display Unit

2 Monitors
Operation Controls
Position Read-out Assembly
Display Unit Electronics

COMPARATOR UNIT

Film Transport Mechanism

70 mm roll film, 100 foot lengths. Manual and/or automatic variable speed film advance, on a frame by frame and/or partial frame basis. (There are two of these.) Frame identification capable of $\pm 90^\circ$ rotation in each channel. Includes condensing optics and photo multiplier readout sensors. Tip/tilt adjustment.

Lens Displacement Mechanism

Lens system capable of translation in x, y, and magnification. Consists of lenses and electromechanical servos and drives in x, y, and magnification.

Light Source and Associated Optics

Backlight, lenses and mirrors necessary to image one scene on the other. Capable of automatic transition from registration to read-out.

Comparator Electronics

Circuitry required to drive electro-mechanical components, i.e., servo motors in the lens displacement mechanism, match point detectors, reference signal generators, etc. Generally, electronics required for registration. Electronics required for generation of flying spot scanner tester. Amplification of video signals for each channel. High voltage supply for photo tubes and CRT.

DISPLAY UNIT

2 Monitors

Comparison scene monitor)	14" TV type monitor
Change Display monitor)	

Operation Controls

- Frame adjust
- Frame advance
- Alignment controls in x,y directions and scale factor for each roll of film
- Initiating controls for automatic registration
- Noise rejection
- Area Blow-up
- Flicker option
- Video gain control for contrast control (for each channel)
- Tip/Tilt Control

Position Read-out Assembly

- + 5% maximum error design goal, measured at the film plane.
- Contractor to explore possibility of area measurement.
- Will provide analog outputs in x and y coordinates, and will display numerical coordinates with respect to the film.

Display Unit Electronics

- Noise rejection circuitry
- All power supplies, except for high voltage supplies for CRT.

OPERATOR OPTIONS

1. Automatic correlation for registration.
2. Manual correlation for registration.
3. Automatic frame advance in both directions.
4. Semi-automatic frame advance in both directions.
5. Minor adjustments within frame with x-alignment control.
6. Change display monitor (Right side).
 - a. Reference scene.
 - b. Change display (black and white changes).
 - (1) Change display minus noise.
 - (2) Changes can be shown in both or either polarity (black/white).
7. Comparison display monitor (Left side).
 - a. Comparison scene.
 - b. Reference scene.
 - c. Reference scene/comparison scene (flicker technique).
8. Flicker technique (left side monitor) (variable speed flicker).
9. Contrast, brightness and gain adjustments (both monitors).
10. Magnification.
 - a. Minimum 5X.
 - b. Area blow-up 6X to 40X, continuously variable.
11. Noise rejection, variable.
12. Position readout (outputs to paper tape or punch cards).